LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA6 | South Ruislip to Ickenham

Flood risk assessment (WR-003-006)

Water resources

November 2013

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Department for Transport

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise three parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the South Ruislip to Ickenham area (CFA6) these are:

- a water resources assessment (Volume 5: Appendix WR-002-006); and
- a flood risk assessment (i.e. this appendix).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Scope and structure of this assessment

1.2.1 This flood risk assessment (FRA) considers the assessment of flood risk in CFA6. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1] which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

1.2.2 The FRA methodology and a review of the relevant local planning policy documents are provided in Section 2 of this report. The design criteria are provided in Section 3, and Section 4 documents the sources of information that have been reviewed. Section 5 provides a description of the planned works within CFA6. Section 6 considers baseline flood risk, and the risk of flooding to the Proposed Scheme from all relevant sources. Flood risk mitigation measures included within the Proposed Scheme are detailed in Section 7. The effect of the Proposed Scheme on the risk of flooding is considered in Section 8.

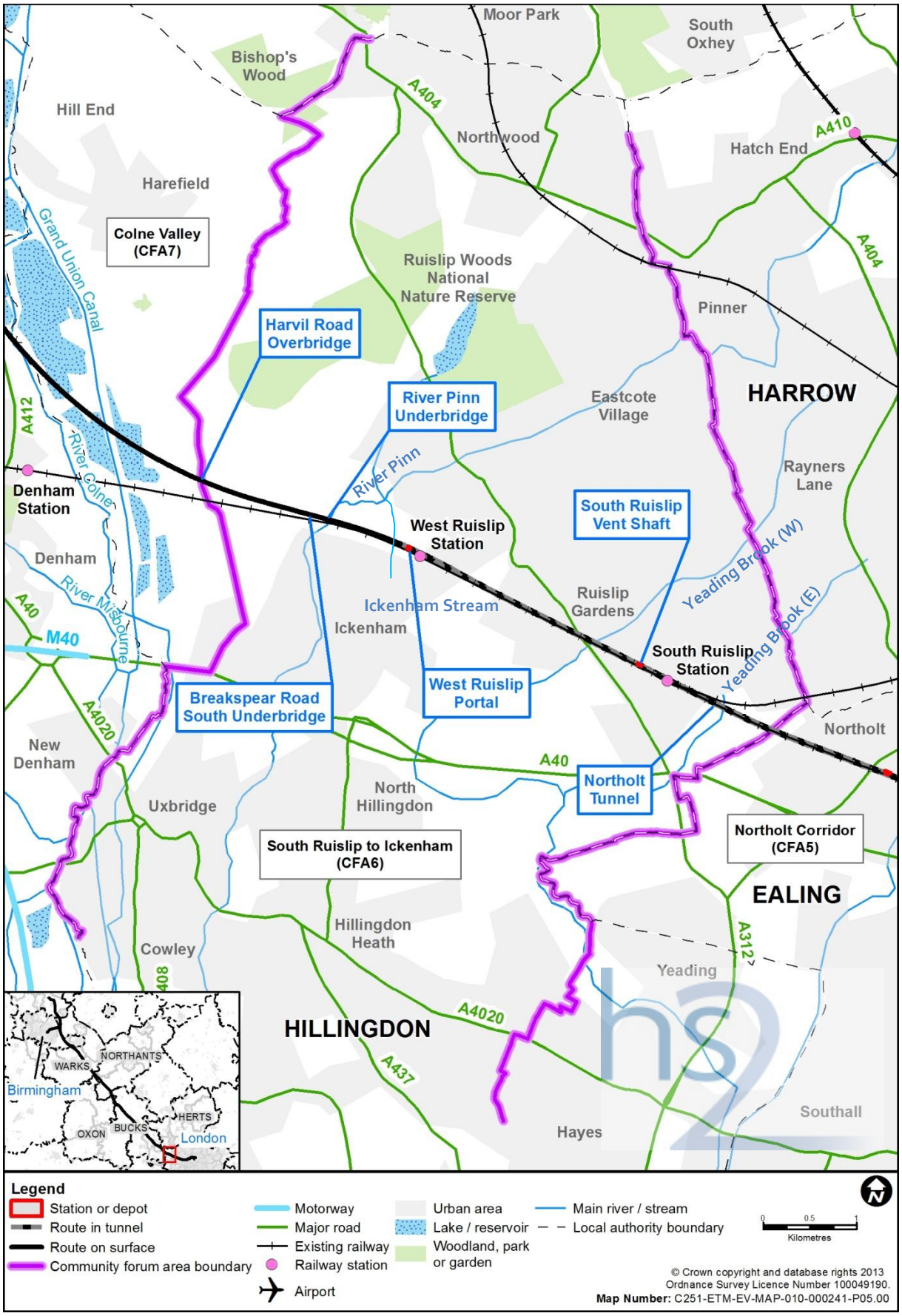
1.3 Location

1.3.1 CFA6 covers a 6.7km section of the Proposed Scheme in the London Borough of Hillingdon (LBHi). The Proposed Scheme extends from a point to the south of Rabournmead Drive in the east to Harvil Road in the west, as shown in Figure 1. The Northolt Corridor area (CFA5) lies to the east and the Colne Valley area (CFA7) lies to the west.

1.3.2 The study area extends to a distance of 500m from the centre line of the route, and includes the urban centres of South Ruislip, Ruislip Gardens, Ruislip Manor, Ruislip, West Ruislip and Ickenham.

[1] Department for Communities and Local Government (2012), *National Planning Policy Framework*

Figure 1: South Ruislip to Ickenham area



1.3.3 The route will cross five watercourses within the study area, as identified using the surface water crossing (SWC) references on Map WR-01-007 (Volume 5, Water Resources and Flood Risk Assessment Map Book), including:

- the east and west arms of the Yeading Brook (SWC-CFA6-01 and SWC-CFA6-04),
- the Ickenham Stream (SWC-CFA6-03);
- the River Pinn (SWC-CFA6-02); and
- the Newyears Green Bourne (SWC-CFA6-10).

2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model individual sources of flooding within the study area are identified. The primary source of flooding is rainfall which is a direct source in the short-term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short or medium-term. Stored rainfall, either naturally in below ground aquifers and natural lakes or artificially in impounded reservoirs and canals can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.

2.1.2 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.3 Receptors considered in this assessment include the Proposed Scheme and existing development within 500m of the Proposed Scheme. The Proposed Scheme includes all associated permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified, mitigation is proposed in line with recommendations in the NPPF.

2.1.4 Existing developments within the study area are identified using Ordnance Survey (OS) mapping information. A high-level screening assessment is then undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways indicated using the flood risk data sources listed below. The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.5 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the Proposed Scheme has any potential to influence or alter the risk of flooding to each receptor. Where such potential has been identified mitigation is proposed based on further analysis.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

[2] Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance.*

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Rivers		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water	No surface water flooding.	Surface water flooding <0.3m for 1 in 200 years event.	Surface water flooding >0.3m for 1 in 200 years event; and Surface water flooding <0.3m for 1 in 30 years event.	Surface water flooding >0.3m for 1 in 30 years event.	
Groundwater		Very low-low	Moderate	High-very high	
Drainage and sewer systems	No sewer in vicinity of site.	Surcharge point >20m from site and no pathways.	Surcharge point within 20m of site and restricted pathways.	Sewer network crosses site and pathways exist.	
Artificial sources	Outside of inundation mapping/no pathway exists.	Within inundation mapping/ pathway exists.			

2.3 Regional and local flooding planning policy documents

2.3.1 The responsibility of Lead Local Flood Authorities (LLFA) within the study area lies with LBHi. In this role, LBHi has produced a preliminary flood risk assessment[3] (PFRA). In addition, LBHi has published a draft surface water management plan [4] which builds upon the high level assessment of the risk of surface water flooding in the PFRA by identifying areas of critical drainage.

2.3.2 The local development framework core strategy[5] for LBHi was adopted in November 2012. To support the core strategy LBHi has also produced a strategic flood risk assessment[6] (SFRA), which has been used as context and to provide baseline data for the assessment of flood risk for CFA6.

London Borough of Hillingdon Preliminary Flood Risk Assessment

2.3.3 The recommendations from the LBHi Preliminary Flood Risk Assessment (PFRA) have been reviewed in undertaking this assessment. The LBHi PFRA forms the first stage of the requirements of the Flood Risk Regulations 2009[7] and identifies historical flooding

[3] Capita Symonds (2011), *London Borough of Hillingdon Preliminary Flood Risk Assessment.*
[4] Capita Symonds (2013), *London Borough of Hillingdon Surface Water Management Plan.*
[5] London Borough of Hillingdon (2012), *Hillingdon Local Plan: Part 1 – Strategic Policies (Adopted November 2012).*
[6] Scott Wilson (2008), *London Borough of Hillingdon Strategic Flood Risk Assessment.*
[7] *Flood Risk Regulations 2009* (SI 2009 No. 3042). London, Her Majesty's Stationery Office.

incidents within the borough as well as providing an understanding of the future flood risk from all sources of flooding other than main rivers.

2.3.4 The LBHi PFRA states that the locally agreed surface water information dataset is from the modelling activities undertaken as part of the Drain London project for the production of the PFRA and surface water management plan. Digital versions of the PFRA mapping outputs have not been made available and therefore the assessment is based on the published maps.

2.3.5 The majority of LBHi lies within the Greater London indicative flood risk area; Ickenham, however, is excluded from the area. The LBHi PFRA assessment supports this exclusion, the assessment concluding that flooding in such sites is unlikely to result in 'significant harmful consequences'. It is recommended in the LBHi PFRA, however, that they are included in the London-wide assessment of flood risk to capture risks arising from elsewhere. The LBHi PFRA did not identify any significant historical or future flood risks from non-river sources within the study area.

London Borough of Hillingdon Draft Surface Water Management Plan

2.3.6 The LBHi surface water management plan evidence base utilises detailed two-dimensional modelling of direct rainfall events to identify areas at significant risk of surface water flooding, and makes use of the Drain London mapping to identify critical drainage areas (CDA). The Proposed Scheme falls within CDA Group1_027 at the eastern extent of CFA6, Group1_018 at Ruislip Gardens, and Group1_021 in the cutting of the Metropolitan Line. The Proposed Scheme will be in tunnel throughout these areas with no above ground infrastructure. CDA Group1_013 lies to the immediate south of the Proposed Scheme to the west of the crossing of the River Pinn. The surface water management plan modelling showed a good correlation to the Environment Agency Flood Map for Surface Water (FMfSW) data.

Thames Region Catchment Flood Management Plan

2.3.7 The Thames Region Catchment Flood Management Plan (CFMP) [8] sets out policies for the sustainable management of flood risk across the Thames Region catchment over the coming 50-100 years taking climate change into account. The study area lies within the catchments of the River Crane, River Pinn and River Colne. The preferred policy for the Crane and Colne catchments is Policy 4, which is for areas of low, moderate or high risk where the Environment Agency are already managing the flood risk effectively but where further action may need to be taken to keep pace with climate change.

2.3.8 The preferred policy for the River Pinn catchment is Policy 6, which is for areas of low to moderate flood risk where the report states that the Environment Agency "will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits".

2.3.9 The Thames Region CFMP recommends that the most sustainable approach to managing future flood risk will be to bring about adaptation of the urban

[8] Environment Agency (2008), *Thames Catchment Flood Management Plan.*

environment. It states that strategic scale planning is key to achieving the needs of the community and managing flood risk in a more sustainable way and that emergency planning is integral to the approach to managing extreme flood events.

London Regional Flood Risk Appraisal

2.3.10 The London Regional Flood Risk Appraisal (RFRA)[9] provides a broad regional understanding of the risk of flooding in Greater London to feed into each of the LLFA SFRA and PFRA reports. Recommendation 7 from the London RFRA states that regeneration and redevelopment of London's river corridors offers a crucial opportunity to reduce flood risk in these areas.

London Borough of Hillingdon Strategic Flood Risk Assessment

2.3.11 The LBHi SFRA states that, in areas at risk of surface water flooding, development should seek to reduce surface water runoff rates as a result of development. It also states that the River Pinn needs to be retained at a high standard as vegetation growth impacts flows and levels. Several policy recommendations are proposed including the following policies specifically relevant to the Proposed Scheme:

- where floodplain storage is removed, the development should provide compensatory storage on a level-for-level basis to ensure there is no loss in flood storage capacity; and
- an 8m buffer strip must be maintained along river corridors.

The London Plan

2.3.12 Policy 5.12 of the London Plan[10] states that development proposals must comply with flood risk assessment and management requirements set out in the NPPF. Policy 5.13 states that development should utilise sustainable drainage systems (SuDS), aiming to achieve greenfield runoff rates unless there are practical reasons why they should not be used.

London Borough of Hillingdon Core Strategy

2.3.13 The LBHi Core Strategy was adopted in November 2012. Policy EM1, which covers adaptation to and mitigation against climate change, is of specific relevance to flood risk and development covering the following points:

- locating and designing development to minimise the probability and impacts of flooding; and
- requiring major development proposals to consider the whole water cycle impact which includes flood risk management, foul and surface water drainage and water consumption.

2.3.14 Policies EM3 and EM6 set out the position of the council towards protection of environmental assets and flood risk management, with a focus on maintaining watercourses and their settings for their biodiversity and recreational value, as well as

[9] Greater London Authority (2009), *London Regional Flood Risk Appraisal.*
[10] Greater London Authority (2008), *The London Plan (consolidated with Alterations since 2004).*

incorporation of SuDS and water recycling schemes to holistically balance water usage and flood risk reduction. Policy EM3 specifically promotes the protection and creation of waterside open space, known as the Blue Ribbon Network.

3 Design criteria

3.1.1 It is a requirement of the design that the Proposed Scheme shall be protected against flooding from any source during the 1 in 1,000 years return period (0.1% annual probability) rainfall event with water levels not rising closer than 1m to the top of rail level.

3.1.2 In accordance with the NPPF, an allowance for climate change is included in the assessment by assuming that peak rainfall intensity will increase by 30% and that peak river flows will increase by 20%.

4 Data sources

4.1 Primary datasets

4.1.1 Consistent with the requirements of the NPPF this assessment considers the risk of flooding from rivers, direct surface water runoff, rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The Proposed Scheme lies entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are presented in Table 2. A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation in the form of hydraulic modelling is undertaken.

Table 2: Flood risk assessment data sources

Source of flooding	Datasets reviewed	Data owner
Rivers	Flood zone mapping. Detailed River Network (DRN). Catchment hydraulic models.	Environment Agency
Surface water	FMfSW. Local surface water flood mapping.	Environment Agency LLFA
Groundwater	Areas susceptible to groundwater flooding. 1:50,000 geological mapping (superficial and bedrock). Potential for elevated groundwater.	British Geological Survey (BGS) LLFA
Drainage and sewer systems	Sewer network plans. Lost river location plans.	Water companies (various) Local planning authority
Artificial sources	Reservoir inundation mapping (RIM). Canal infrastructure locations. Trunk water main asset plans.	Environment Agency Canal & River Trust Water companies (various)

4.2 Site familiarisation visits

4.2.1 A site familiarisation visit was undertaken in January 2013 to the River Pinn, Ickenham Stream and the Newyears Green Bourne at Harvil Road.

5 The proposed development

5.1 Topography and land use

5.1.1 The topography of the study area is generally flat with a small rise and fall between Breakspear Road South and Harvil Road at the western end of this section of the Proposed Scheme.

5.1.2 The area is predominantly suburban in character in the east and becomes more rural in character to the north and north-west of Ickenham. The area has a mixed land use pattern of residential properties, industry, open space, farmland and road and rail links. The Proposed Scheme will pass to the south of South Ruislip and Ruislip Manor and to the north of Ruislip Gardens and Ickenham.

5.1.3 The eastern and western arms of Yeading Brook flow in a north to south direction through the area and will be crossed by the Proposed Scheme in the vicinity of Victoria Road/Civic Way and to the west of London Underground (LU) Ruislip Gardens Station. The River Pinn also flows in a north to south direction through the area and will cross the Proposed Scheme to the east of the Breakspear Road South. The Newyears Green Bourne will be crossed by Harvil Road at the western end of this section of the Proposed Scheme.

5.2 Local flood risk receptors

5.2.1 The vulnerability of each local receptor with an identified pathway within the study area is presented in Table 3. The vulnerability is classified in accordance with the recommendations of Table 2 in the NPPF technical guidance document and the Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2).

Table 3: Vulnerability of local receptors in CFA6

Local receptor	Description	Vulnerability classification	Source/pathway
South Ruislip industrial area	Industrial park and warehousing	Less vulnerable	Surface water 30 years - shallow
South Ruislip urban centre	Residential dwellings and associated infrastructure	More vulnerable	Flood Zone 2 and Flood Zone 3
Ruislip Gardens urban centre	Residential dwellings and associated infrastructure	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 30 years - deep
Ruislip Gardens LU Depot	Railway maintenance infrastructure	More vulnerable	Groundwater - high
West Ruislip LU Station	Railway infrastructure	More vulnerable	Surface water 200 years - shallow
The Greenway, West Ruislip	Residential dwellings	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow
Ruislip Golf Course	Recreation	Water compatible	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow

Local receptor	Description	Vulnerability classification	Source/pathway
Oak Farm, Square Orchard and Old Priory	Residential dwellings	More vulnerable	Edge of Flood Zone 2 and Flood Zone 3
Highway Farm	Agriculture and residential dwelling	Less vulnerable/ more vulnerable	Edge of Flood Zone 2 and Flood Zone 3
Schering-Plough Animal Research Facility	Research laboratories	Less vulnerable	Surface water 200 years - shallow
Chiltern Main Line (CML) cutting	Railway infrastructure	More vulnerable	Surface water 200 years - shallow

5.3 Description of the Proposed Scheme

5.3.1 The Proposed Scheme through this area will be approximately 6.7km in length. It will enter the area in tunnel at the boundary with CFA5 directly south of Rabournmead Drive, South Ruislip. It will then proceed to the north-west in tunnel for approximately 4.4km at an average depth of approximately 30m below ground level. A ventilation and intervention shaft (South Ruislip vent shaft) will be located on former industrial land at South Ruislip.

5.3.2 A tunnel portal will be constructed at West Ruislip approximately 70m west of Ickenham Road. The Ickenham Stream (canal feeder) will be diverted on the north side of the ramp structure westwards to the River Pinn. After gradually returning to the surface on a ramp within the portal structure, the route will be on embankment with bridges across the River Pinn and Breakspear Road South.

5.3.3 West of Breakspear Road South the route will initially be on embankment and then in a cutting which will extend to the boundary with CFA7 at Harvil Road, Ickenham. A temporary railhead will be provided between Breakspear Road South and Harvil Road to facilitate construction works and allow removal of excavated material. A permanent siding for maintenance equipment will be provided west of Breakspear Road South.

5.3.4 A section of Harvil Road, approximately 750m in length, will be realigned approximately 75m to the east of its current location and raised by a maximum of 10m to cross over the route of the Proposed Scheme. This will require three new bridges on the realigned Harvil Road over the Proposed Scheme, the CML and Newyears Green Bourne. A balancing pond will be required to the north of the Proposed Scheme and west of the realigned Harvil Road for highway drainage. The Ickenham auto-transformer feeder station will be located just west of the realigned Harvil Road, to the south of the Proposed Scheme, with an associated access from Harvil Road. This will be located mainly in CFA7 and partly within CFA6. A replacement floodplain storage area, directly south of Newyears Green Bourne and east of the realigned Harvil Road, will be excavated and regraded to tie back into the existing ground level.

5.3.5 Key features of the Proposed Scheme are shown on Maps CT-06-015 to CT-06-020b.

6 Existing flood risk

6.1 Historical flooding incidents

6.1.1 The LBHi SFRA identifies that substantial historical flooding occurred on the River Pinn in 1977 when residential and non-residential properties were affected. Following this flooding event the River Pinn Flood Alleviation Scheme was implemented and included channel improvement works between 1980 and 1989. Records indicate that further flooding occurred in 1984, 1987, 1988, and in 2000 and 2001 after the completion of the River Pinn Flood Alleviation Scheme.

6.1.2 Historical river flooding is also shown in the LBHi PFRA on the western arm of the Yeading Brook close to Ruislip Gardens LU Station. Historic photographs suggest that Berkeley Close in Ruislip Gardens flooded to a depth of around 0.3m in 1959. There are no incidents of historical surface water flooding identified in the LBHi PFRA within the study area.

6.1.3 The LBHi PFRA identifies two historical incidents of groundwater flooding within the study area. One from Environment Agency records within the Herlwyn Avenue estate and one from other records close to West Ruislip Station.

6.1.4 According to the LBHi SFRA a total of 164 properties have flooded in the borough from overloaded sewers in the past ten years; 63 from foul water drainage systems, 93 from surface water sewers, and eight properties have been affected by flooding from combined systems. The LBHi PFRA shows that the location with the highest occurrence of sewer flooding incidents within the study area is close to Ruislip Gardens to the north of the Northolt Royal Air Force base where 21-50 properties are shown to have flooded.

6.2 Risk of flooding from rivers

6.2.1 Within CFA6 the Proposed Scheme will cross the flood zones of both arms of the Yeading Brook, the Ickenham Stream, the River Pinn, and the Newyears Green Bourne.

Yeading Brook (western and eastern arms) at South Ruislip

6.2.2 The Proposed Scheme will pass in tunnel beneath both arms of the Yeading Brook close to South Ruislip. These are small, heavily urbanised watercourses with relatively wide flood zones that are believed to be due to the presence of culverts. The closest above ground infrastructure to these watercourses will be the South Ruislip vent shaft.

6.2.3 The Environment Agency has provided detailed hydraulic modelling of the River Crane catchment, including the Yeading Brook western and eastern arms. At the proposed crossing of the Proposed Scheme with the Yeading Brook western arm:

- the 1 in 100 years return period (1% annual probability) flood water level is 36.4m above Ordnance Datum (AOD);
- the 1 in 100 years return period (1% annual probability) flood water level

including a 20% allowance for climate change is 36.5m AOD; and

- the 1 in 1,000 years return period (0.1% annual probability) flood water level is 37.4m AOD.

6.2.4 Flood water levels at the Yeading Brook eastern arm are lower than at the western arm and the extent of predicted flooding is further away from the proposed South Ruislip vent shaft than the flooding at the western arm.

6.2.5 Ground levels at the proposed location of the South Ruislip vent shaft are approximately 43-44m AOD and there will therefore be at least a 5.6m freeboard for the entrance to the shaft and the 1 in 1,000 years return period (0.1% annual probability) flood water level for the Yeading Brook western arm.

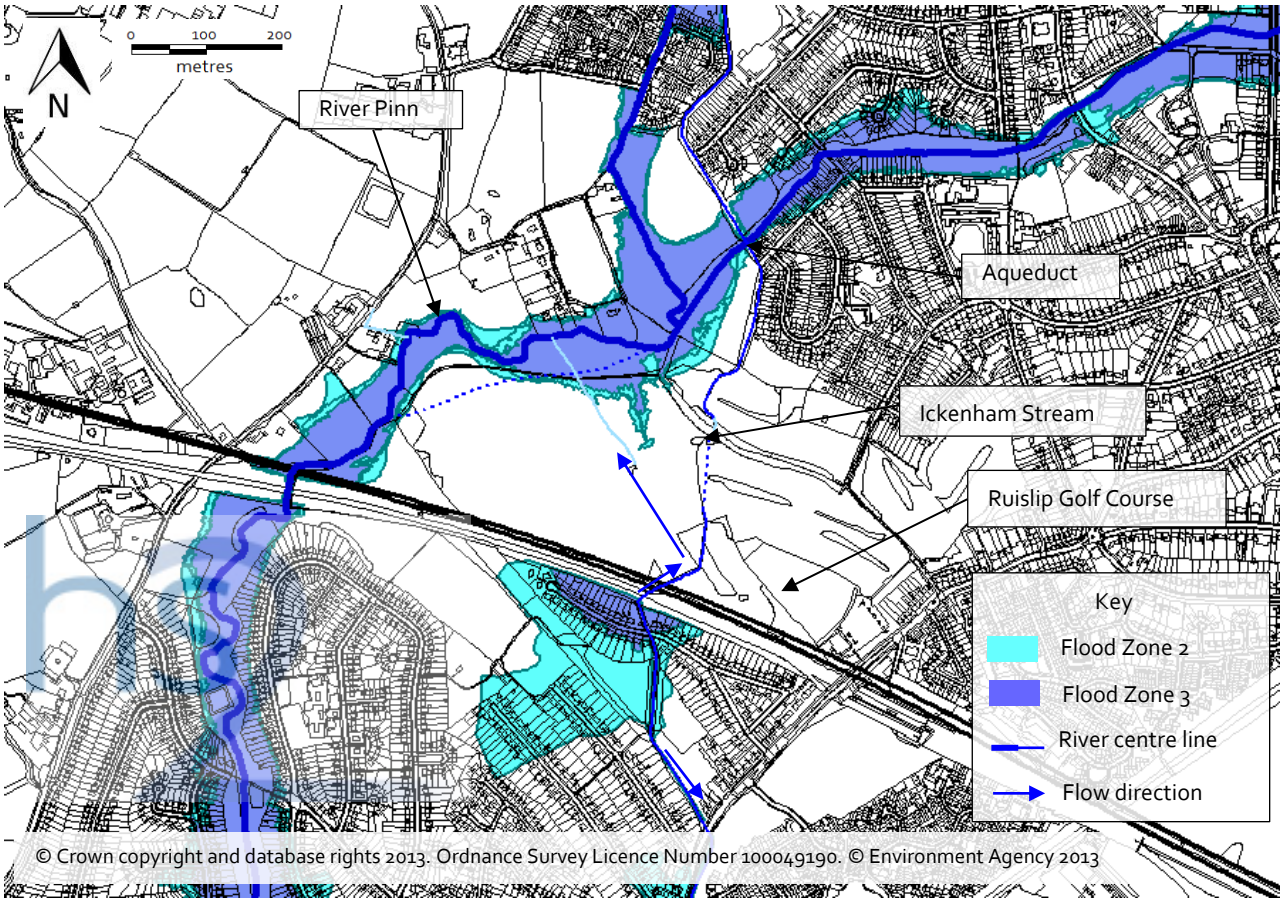
6.2.6 There will be a low risk of flooding to the Proposed Scheme at the South Ruislip vent shaft from the Yeading Brook western arm.

Ickenham Stream at Ruislip Golf Course

6.2.7 The route will cross the Ickenham Stream and its associated floodplain to the south of Ruislip Golf Course. The Ickenham Stream was originally constructed as a feeder for the Grand Union Canal from the Ruislip Lido reservoir and is carried over the River Pinn on an aqueduct close to Woodville Gardens. The Ickenham Stream now collects surface water and is classified as a LLFA 'Ordinary Watercourse' as far south as the existing CML, downstream of which the watercourse is an Environment Agency classified 'Main River'. Baseline flood risk is shown on Map WR-01-007 (Volume 5, Water Resources and Flood Risk Assessment Map Book) and a schematic of the watercourses in this area is provided in Figure 2.

6.2.8 The Environment Agency model of the River Crane, which includes the Ickenham Stream, uses the culvert beneath the existing railway line as the upstream model boundary for the Ickenham Stream which is consistent with observations made during the site familiarisation visit. Where the Ickenham Stream will be crossed by the Proposed Scheme there is no modelled associated floodplain as this is upstream of the culvert.

Figure 2: Environment Agency digital river network and Flood Zone maps at the Ickenham Stream and River Pinn.



6.2.9 Where the Proposed Scheme will cross the Ickenham Stream it will be in a retained cut on the approach to the West Ruislip portal, as shown on Map CT-06-018 (Volume 2, CFA6 Map Book). The Ickenham Stream to the north of the Proposed Scheme will be diverted along the northern edge of the excavation. In this location the ground is falling to the north and west and therefore there is not expected to be significant flows within this diverted watercourse. The diversion will be designed to ensure adequate conveyance and is likely to be incorporated into the existing drainage infrastructure for Ruislip Golf Course.

6.2.10 To the south of the existing rail embankment there is a small catchment where the topography falls to the north as shown in Figure 3. This catchment is picked up in river and surface water flood modelling. In this location the modelled 1 in 100 years return period (1% annual probability) flood water level is 42.3m AOD with surrounding ground levels at approximately 42.0m AOD. This rises to 43.2m AOD for the 1 in 1,000 years return period (0.1% annual probability) flood event. As this watercourse is at the upstream boundary of the Environment Agency model, and the topography falls towards the boundary node, water levels in this location cannot be relied upon.

Figure 3: Ickenham Stream during site visit (January 2013) looking south at existing crossing of the Chiltern Main Line

6.2.11 There will be a diversion of the public right of way (PRoW) that currently passes through the existing CML embankment in a twinned culvert (with the western culvert containing the PRoW and the eastern culvert containing the Ickenham Stream). This PRoW is proposed to be diverted to the east between the CML and the West Ruislip portal before crossing over the Proposed Scheme on the Ickenham Stream (Canal Feeder) footbridge. The western culvert will therefore be retained and will maintain a flowpath from the small catchment to the south of the CML close to The Greenway to the north of the CML. Surface water runoff will be collected and attenuated before being discharged to the diverted Thames Water Utilities Limited (TWUL) sewer that will be approximately 15m to the west of the existing culvert. The West Ruislip portal has an upstand that is approximately 0.5m in height at this location above surrounding ground levels.

6.2.12 There will be a low risk of flooding to the Proposed Scheme at the West Ruislip portal from the small catchment of the Ickenham Stream to the south of the CML embankment.

River Pinn at Ruislip Golf Course

6.2.13 The River Pinn is an Environment Agency 'Main River' and has a catchment size of 29km^2 at the Proposed Scheme crossing location, resulting in 1 in 100 years return period (1% annual probability) flood flows of approximately 35m^3/s (calculated using the Revitalised Flood Hydrograph rainfall runoff method). The Proposed Scheme will cross approximately 180m of Flood Zone 3 and 200m of Flood Zone 2. Approximately 60m of the river centre line lies perpendicular to the Proposed Scheme within the 50m buffer.

6.2.14 The Environment Agency has provided detailed hydraulic modelling of the River Pinn. The following flood water levels were extracted immediately upstream of the crossing:

- 1 in 100 years return period (1% annual probability) flood water level of 38.83m AOD, corresponding to a modelled flow of approximately 20m^3/s;
- 1 in 100 years return period (1% annual probability) flood water level including a 20% allowance for climate change of 38.89m AOD, corresponding to a modelled flow of approximately 24m^3/s; and
- 1 in 1,000 years return period (0.1% annual probability) flood water level of 39.01m AOD, corresponding to a modelled flow of approximately 31m^3/s.

6.2.15 At the River Pinn underbridge the Proposed Scheme will diverge from the existing CML and cross the river approximately 30m north of an existing viaduct as shown on Map CT-06-018, B6 (Volume 2, CFA6 Map Book). The floodplain of the River Pinn is currently constrained beneath a two-span brick arch crossing, which is approximately 10m wide, and has a soffit approximately 6m above ground level. The channel of the River Pinn passes through the western archway of the viaduct and is brick lined throughout this section. According to the modelled floodplain and flood zones the restriction of the CML viaduct causes backing up of flood flows on the northern side of the embankment.

Figure 4: Existing railway bridge over the River Pinn looking south

6.2.16 The crossing at this location will be formed of a 24m wide bridge to cross both the River Pinn and the Breakspear Road to Hoylake Crescent PRoW. The proposed span length accommodates the river channel and banks. The rail height will rise from 47.1m AOD to 48.9m AOD at Breakspear Road South. The rail level at the River Pinn will be approximately 48.7m AOD.

6.2.17 The River Pinn is currently tightly constrained under the existing viaduct downstream of the new crossing. Flood water levels vary from 38.8m AOD in the 1 in 100 years return period (1% annual probability) flood event to 39.0m AOD in the 1 in 1,000 years return period (0.1% annual probability) flood event immediately upstream of the existing overland viaduct.

6.2.18 The River Pinn underbridge will be designed to span the River Pinn with no intermediary piers, and the minimum soffit will be set approximately 8m above the existing ground level. The width of the River Pinn underbridge is significantly greater than the existing downstream crossing and therefore no significant flood flow obstruction is expected. The footpath crossing of the River Pinn will continue to use the existing footbridge.

6.2.19 The rail level of the Proposed Scheme will be at 10m above the modelled 1 in 1,000 years return period (0.1% annual probability) flood water levels. The risk of flooding to the Proposed Scheme from the River Pinn is therefore low.

Newyears Green Bourne at Harvil Road

6.2.20 Harvil Road currently crosses the Newyears Green Bourne (upstream 5km^2 catchment). The road is currently on embankment across the floodplain with a culvert conveying the stream beneath the roadway. The 1 in 100 years return period (1% annual probability) flood flow is approximately 6m^3/s.

6.2.21 Harvil Road is to be permanently realigned as part of the design as shown on Map CT-06-019 (Volume 2, CFA6 Map Book). The existing crossing is on embankment through the floodplain with flows in the Newyears Green Bourne conveyed within culvert beneath the road. Comparison of flood zone outlines with light detection and ranging (LiDAR) data suggests the 1 in 1,000 years return period (0.1% annual probability) flood water level is approximately 39.5m AOD. Harvil Road is at a level of 39.1m AOD and may therefore be currently at risk of flooding. The Proposed Scheme will include a culvert beneath embankment of the Harvil Road overbridge. The road level at the crossing will fall from 47.4m AOD to 45.9m AOD and with a corresponding deck depth of approximately 2m; the minimum soffit level at the crossing will be 43.9m AOD which is 4.4m above the estimated maximum flood water level.

6.2.22 The Proposed Scheme will lie approximately 150m to the south of the Harvil Road crossing of the Newyears Green Bourne with rail levels set at approximately 47.6m AOD. The rail level will therefore be significantly higher than the 1 in 1,000 years return period (0.1% annual probability) flood water level.

6.2.23 There will be no significant risk of flooding to the Proposed Scheme from the Newyears Green Bourne at the Harvil Road diversion, nor will there be a flood risk to the carriageway of the diverted Harvil Road.

6.3 Risk of flooding from surface water

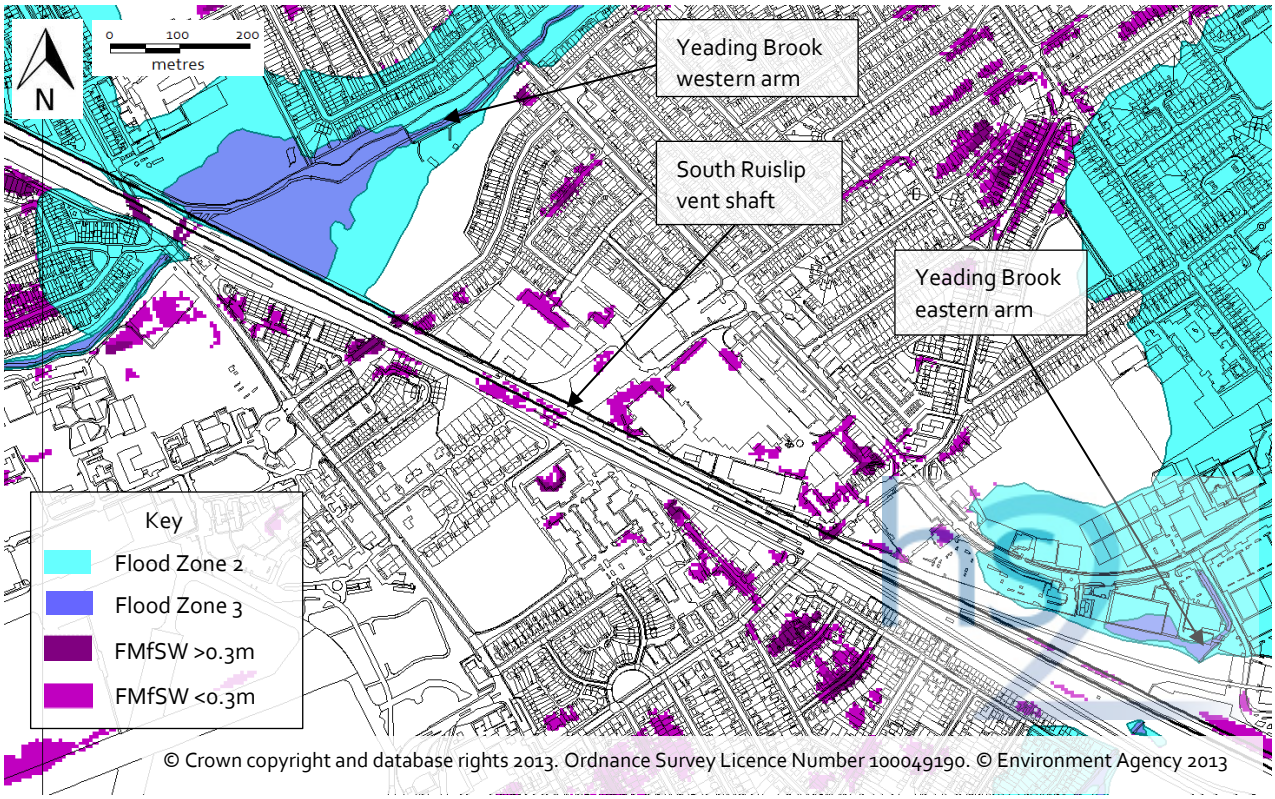
6.3.1 The modelling outputs of the LBHi PFRA and the Environment Agency FMfSW have been reviewed to form the basis of the assessment of the risk of surface water flooding in CFA6.

6.3.2 There are areas within the study area that are shown to have a high risk of surface water flooding. As the Proposed Scheme is within tunnel for parts of the study area the surface water flood risk has been considered only in the location of permanent above-ground infrastructure.

South Ruislip vent shaft

6.3.3 Surface water flooding datasets show isolated areas of the now vacant Arla Dairy site in South Ruislip to be at risk of shallow surface water flooding during the 1 in 30 years return period (3.33% annual probability) and 1 in 200 years return period (0.5% annual probability) flood events (presented in Figure 5). The South Ruislip vent shaft will be located to the south of Tiptree Road and is adjacent to the CML and London Underground Central Line tracks. Shallow surface water flooding is also predicted within the track beds of the adjacent railway lines.

Figure 5: 1 in 200 years return period (0.5% annual probability) surface water flood extents and Environment Agency Flood Zone Map at South Ruislip vent shaft.



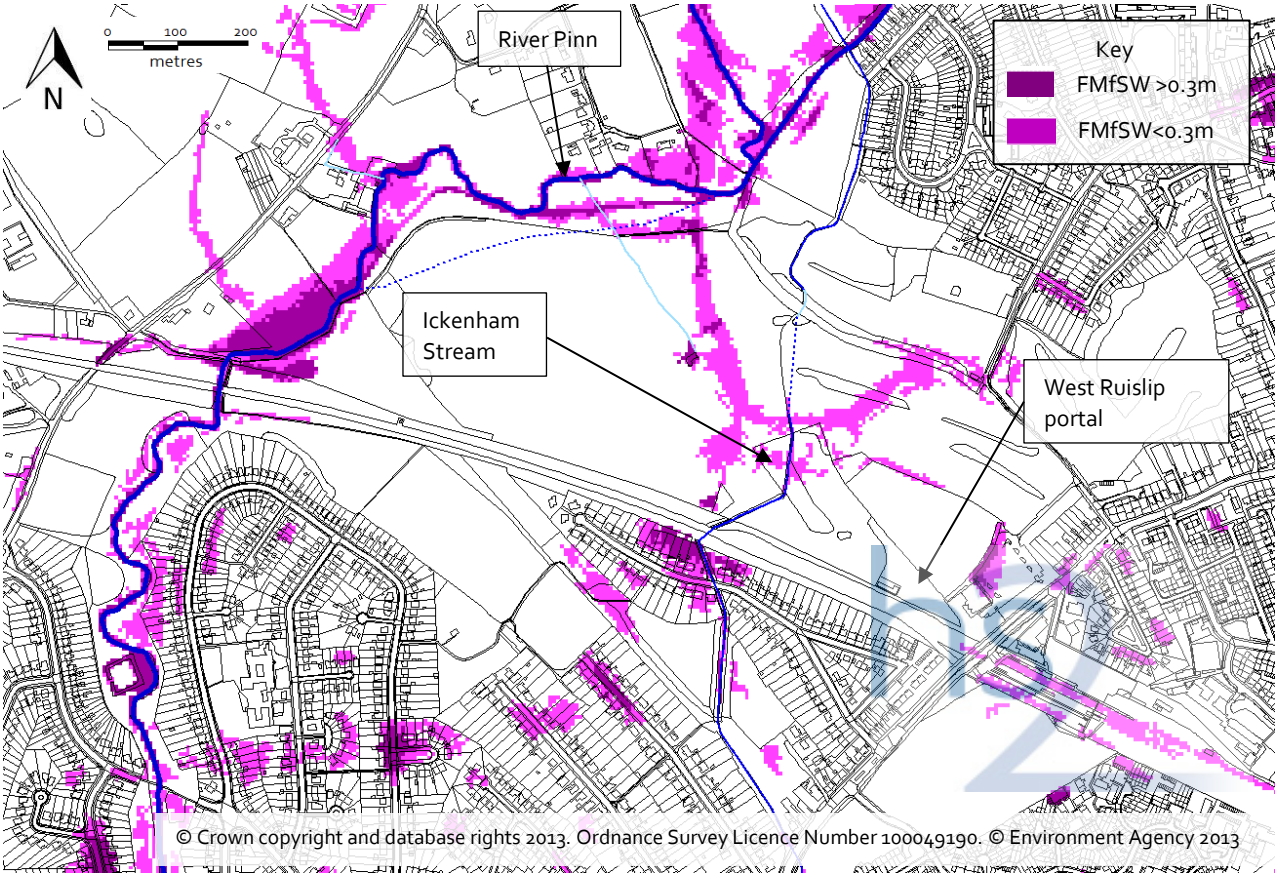
6.3.4 Drainage provisions will be provided for the shaft headhouse and will be designed to store the 1 in 100 years return period (1% annual probability) flood, including a 30% allowance for climate change. There are no flowpaths crossing the site of the proposed vent shaft and the site is not located within an area identified in the LBHi Surface Water Management Plan as a CDA.

6.3.5 There will be no significant risk of surface water flooding to the Proposed Scheme at the South Ruislip vent shaft.

Ruislip Golf Course

6.3.6 Surface water flooding datasets show isolated areas of Ruislip Golf Course to be at risk of shallow surface water flooding during the 1 in 30 years return period (3.33% annual probability) and 1 in 200 years return period (0.5% annual probability) flood events, upstream of the floodplain of the River Pinn (Figure 6).

Figure 6: 1 in 200 years return period (0.5% annual probability) surface water flood at Ruislip Golf Course.



6.3.7 The topography in this area is sloping from south to north and therefore primary flowpaths within the surface water flood risk areas are to the north and west towards the River Pinn.

6.3.8 There will be no significant risk of surface water flooding to the Proposed Scheme at Ruislip Golf Course.

Chiltern Main Line to the north of Copthall Covert

6.3.9 The track bed of the CML to the east of West Ruislip is identified in the LBHi Surface Water Management Plan as a CDA (reference Group1_013) and is shown on surface water flooding datasets to be at risk of shallow surface water flooding during the 1 in 30 years (3.33% annual probability) and 1 in 200 years (0.5% annual probability) flood events.

6.3.10 The surface water management plan states that modelling results indicate that the area is prone to flooding due to the overland runoff within the local catchment

converging on the low elevations within the CDA. Although confidence in the modelling results is high the actual drainage infrastructure for the CML is unknown and was not included in the surface water management plan modelling. The LBHi SFRA states that this section of CML is considered critical transport infrastructure of national importance.

6.3.11 Excavation work is proposed adjacent to the existing cutting, with a cutting identified to the north of Copthall Covert. Landscape mitigation earthworks will be provided between the existing cutting and the proposed Copthall Covert cutting.

6.3.12 There will be no significant risk of surface water flooding to the Proposed Scheme to the north of Copthall Covert from the existing cutting of the CML.

6.4 Risk of flooding from groundwater

6.4.1 Geological mapping indicates that superficial deposits are present at the western end of the study area and comprise a narrow ribbon of alluvium associated with the River Pinn.

6.4.2 The bedrock geology comprises an outcrop of the Lambeth Group present to the north of the Proposed Scheme at Ruislip Gardens Station and also approximately 200m either side of the River Pinn. In this area it is described as mottled sandy clay and clayey sand. The bedrock geology underlying the remainder of the study area is the London Clay Formation. The Lambeth Group is directly underlain by the Cretaceous Chalk Group in this area.

6.4.3 The LBHi PFRA shows isolated areas within the study area to have an increased potential for elevated groundwater in the permeable superficial deposits at the Ruislip Gardens LU Depot and at the River Pinn.

6.4.4 The Proposed Scheme will be in tunnel through the area at risk at Ruislip Depot and above ground on embankment and viaduct through the area at risk at the River Pinn. There will be no significant risk of groundwater flooding to the Proposed Scheme within the study area.

6.5 Risk of flooding from drainage systems

6.5.1 The Proposed Scheme will cross a number of urban centres within the study area and therefore above ground infrastructure will be located close to the existing sewer network and associated manholes. The LBHi PFRA and SFRA report a number of historical incidents of sewer flooding; the exact location of these incidents, however, is not available.

6.5.2 The sewer network in this area is predominantly combined and therefore the risk of flooding from sewers is considered to be comparable to the risk of flooding from surface water sources that has been previously described.

6.5.3 Surface water runoff from permanent infrastructure will be attenuated before being discharged to a local watercourse or to the public sewer network. Consents to discharge will be obtained prior to construction from the necessary statutory authorities to ensure that there is sufficient capacity in the receiving infrastructure.

6.5.4 There will therefore be no additional significant risk of flooding from drainage and sewer systems to the Proposed Scheme within the study area beyond that already specified in Section 6.3 of this report that addresses the risk of flooding from surface water sources.

6.6 Risk of flooding from artificial sources

Canals

6.6.1 There will be no canal crossings within the study area and there are no canals in the vicinity of the Proposed Scheme that could pose a flood risk within the study area.

Reservoirs

6.6.2 The Proposed Scheme will cross an area that is shown on the Environment Agency RIM to have a residual risk of flooding from Ruislip Lido at the crossing of the River Pinn. This reservoir historically fed the Grand Union Canal by way of an artificial watercourse and is owned by LBHi.

6.6.3 In response to planned improvements by LBHi at Ruislip Lido in 2011 a flood risk assessment[11] was undertaken by Halcrow to assess the current risk of flooding and the possible changes in water level. The Ruislip Lido FRA notes that historical flooding occurred downstream of the Lido on Cannon Brook in the 1980s and consequently the normal water level was lowered in order to prevent or limit any outflow from the Ruislip Lido.

6.6.4 In addition, the Reservoirs Act 1975[12] (as amended by the Flood and Water Management Act 2010[13]) requires reservoir owners to maintain retaining structures such that the annual probability of a breach of the reservoir is 1 in 50,000.

6.6.5 Although there is the potential to have an impact on the residual risk of flooding from the reservoir the likelihood of such flooding occurring is extremely low and is therefore not considered further in detail within this assessment.

Water mains

6.6.6 The Proposed Scheme will cross a number of trunk water mains in tunnel throughout the study area. Information regarding the diameters and locations of trunk water mains maintained by Affinity Water (the public water supply company for the study area) is not currently available. Water mains that could be affected by ground movement caused by tunnelling or excavation works will be assessed prior to construction to ensure their structural integrity prior to construction.

6.6.7 There will therefore be no significant risk of flooding from water mains to the Proposed Scheme within the study area.

[11] Halcrow (2011), *Ruislip Lido Improvement Programme: Flood Risk Assessment*, London Borough of Hillingdon.
[12] *Reservoirs Act 1975* (c.23). London, Her Majesty's Stationery Office.
[13] *Flood and Water Management Act 2010* (c.29). London, Her Majesty's Stationery Office.

6.7 Summary of baseline flood risk

Table 4: Summary of baseline flood risk for all sources of flooding in CFA6

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Ickenham Stream	Ruislip Golf Course	High Close to Flood Zone 3a	West Ruislip portal	Risk of flooding to the West Ruislip portal from the small catchment of the Ickenham Stream to the south of the CML embankment
River Pinn	Ruislip Golf Course	High Flood Zone 3a	River Pinn underbridge	Sufficient freeboard from 1,000 year flood water levels to track
Groundwater	Ruislip Gardens	High	N/A	Proposed Scheme will be in tunnel
Surface water	South Ruislip industrial area	Low 200 years - shallow	South Ruislip vent shaft	No overland flowpaths present Drainage system will collect and attenuate runoff
Surface water	Ruislip Golf Course	Medium 200 years - deep	West Ruislip portal	Risk of flooding to the West Ruislip portal from the small catchment of the Ickenham Stream to the south of the CML embankment
Surface water	CML near Copthall Covert	Low 200 years - shallow	Cutting between Brakespear Road and Harvil Road	Landscape mitigation earthworks will separate surface water catchments
Artificial sources – Ruislip Lido	River Pinn	Low Artificial source with pathway	River Pinn underbridge	The Proposed Scheme will be on a bridge over the River Pinn
Artificial sources – water main	N/A	No risk Source but no pathway	South Ruislip vent shaft West Ruislip portal	Excavation will be too far from source to pose risk of flooding

7 Flood risk management measures

7.1 Risk of flooding from rivers

7.1.1 The Proposed Scheme will be raised above crossings of river floodplains such that the risk of flooding from this source will be less than 0.1%. Therefore the embedded mitigation ensures that there are no instances where the Proposed Scheme will be at significant risk of river flooding and consequently no specific mitigation is required.

7.1.2 At the crossings of the River Pinn and Newyears Green Bourne, replacement floodplain storage will be provided upstream of the Proposed Scheme to mitigate for all losses in floodplain storage. Land has been made available in the design of the Proposed Scheme for such areas.

7.2 Risk of flooding from surface water

7.2.1 There are no locations where the rail level of the Proposed Scheme will be less than 1m above ground level in an area shown to be at risk of flooding from direct surface water runoff. Consequently no specific mitigation is required.

7.2.2 Potential increases in peak discharge rates will be attenuated from all permanent infrastructure prior to discharge, with discharge rates to be agreed with TWUL. Consequently no specific additional mitigation is required.

7.3 Risk of flooding from groundwater

7.3.1 There will be no risk of flooding from groundwater to the Proposed Scheme, nor will there be any anticipated effects on the risks of flooding from groundwater within the study area arising from the Proposed Scheme. Consequently no specific mitigation is required.

7.4 Risk of flooding from drainage systems

7.4.1 There will be no risk of flooding from drainage systems to the Proposed Scheme, nor will there be any anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Consequently no specific mitigation is required.

7.5 Risk of flooding from artificial sources

7.5.1 There are no instances where the Proposed Scheme will be at significant risk of flooding from artificial sources and consequently no specific mitigation is required.

7.5.2 Due to the extremely low probability of flooding due to a breach of Ruislip Lido and the likely low significance of any impacts arising from the Proposed Scheme, it is not considered necessary to provide additional mitigation for this scenario.

8 Post-development flood risk assessment

8.1 Local receptors

8.1.1 In addition to the risk of flooding that exists to the Proposed Scheme, there is potential for the Proposed Scheme to affect the risk of flooding to third party receptors by altering flow mechanics across the range of flood sources. All local receptors with a potential flood risk are identified in Section 5.2 of this report. For the Proposed Scheme to have an impact on a given receptor, the identified pathway for that receptor must be shared by both the subject receptor and the Proposed Scheme, with the result that a number of cases can be excluded immediately. Table 5 summarises the shared pathways between the Proposed Scheme and each receptor, and identifies cases where no shared pathway exists.

Table 5: Shared flood risk pathways in CFA6

Local receptor	Vulnerability classification	Pathway	Shared pathway between Proposed Scheme and receptor
South Ruislip industrial area	Less vulnerable	Surface water 30 years - shallow	South Ruislip vent shaft.
South Ruislip urban centre	More vulnerable	Flood Zone 2 and Flood Zone 3	Yeading Brook eastern arm – Proposed Scheme will be in tunnel (No shared pathway).
Ruislip Gardens urban centre	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 30 years - deep	Yeading Brook western arm – Proposed Scheme will be in tunnel (No shared pathway).
Ruislip Gardens LU Depot	Less vulnerable	Groundwater - high	Northolt tunnel.
West Ruislip LU Station	Less vulnerable	Surface water 200 years - shallow	No shared pathway.
The Greenway, West Ruislip	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow	Ickenham Stream - West Ruislip portal will be upstream.
.Ruislip Golf Course	Water compatible	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow	River Pinn underbridge, Ickenham Stream diversion and River Pinn approach embankments.
Oak Farm, Square Orchard and Old Priory	More vulnerable	Edge of Flood Zone 2 and Flood Zone 3	River Pinn underbridge, Ickenham Stream diversion and River Pinn approach embankments.
Schering-Plough Animal Research Facility	Less vulnerable	Edge of Flood Zone 2 and Flood Zone 3	Breakspear Road to Harvil Road cutting.
CML cutting	Less vulnerable	Surface water 200 years - shallow	Breakspear Road to Harvil Road cutting.

8.1.2 There is also the potential for the Proposed Scheme to change the baseline risk of flooding described in the Section 6 of this report. Though designed such that the

probability of the Proposed Scheme flooding in any given year is less than 1 in 1,000, any change to the baseline risk of flooding could impact on the assessment of flood risk to the Proposed Scheme. All cases of flood risk discussed in Section 6 of this report are therefore reconsidered regardless of the presence or otherwise of third party local receptors.

8.2 Impact on risk of flooding from rivers

Ickenham Stream at Ruislip Golf Course

8.2.1 The Proposed Scheme will not cross the modelled floodplain of the Ickenham Stream. Flow in the watercourse to the north of the Proposed Scheme will be diverted along the northern extent of the earthworks to an outfall with the River Pinn. The diversion will be designed to match the existing conveyance of the watercourse.

8.2.2 The proposed diversion of the Ickenham Stream has the potential to affect the risk of flooding at three locations. Locally, the diversion of flows to the River Pinn could increase the risk of flooding in the Pinn catchment and similarly reduce the risk of flooding in the Yeading Brook catchment and along the Ickenham Stream south of the crossing.

8.2.3 Due to the artificial nature of the watercourse current flow volumes in the stream are unknown. A site familiarisation visit, however, has shown that modifications to the channel, including regrading and diversion to create additional water hazards within the Ruislip Golf Course, already result in the majority of the baseflow for the stream discharging into the River Pinn catchment to the west. Further, the general topography of the golf course falls towards the River Pinn, suggesting that any out of channel flow is likely to discharge westwards to the river rather than reversing flows through the existing railway culvert. Local receptors include Ruislip Golf Course.

8.2.4 Consequently, for a diversion channel between the crossing location and the River Pinn there will be a negligible change in the local contributing catchments and consequently no significant alteration to the risk of flooding in the local area.

8.2.5 The volume and runoff rates for any flood water that is collected within the small catchment to the south of the CML at the Ickenham Stream are unknown. The upstand to the West Ruislip portal will prevent flood water from continuing to the north towards the River Pinn. Surface water runoff will be collected and a connection will be provided to the diverted TWUL sewer to the west of the existing culvert. This will prevent the backing up of flood water within the culvert. Local receptors include a number of residential dwellings in The Greenway.

8.2.6 There will not be an increase in the risk of flooding to the immediate south of the Proposed Scheme at the crossing of the Ickenham Stream. There will be no change in the risk of flooding to the north of the West Ruislip portal on the Ickenham Stream.

River Pinn at Ruislip Golf Course

8.2.7 At the River Pinn underbridge, the route will diverge from the existing CML and cross the river approximately 30m north of an existing viaduct. The floodplain of the River Pinn is currently constrained beneath this two-span brick arch crossing which is

approximately 10m wide in total with a soffit approximately 6m above ground level. The channel of the River Pinn passes through the western archway of the viaduct. According to the modelled floodplain and flood zones the restriction of the CML viaduct causes backing up of flood flows on the northern side of the embankment.

8.2.8 The crossing at this location will be formed of a 24m wide bridge to cross both the River Pinn and the Breakspear Road to Hoylake Crescent footpath. The proposed span length accommodates the river channel and banks, plus 8m wide buffer strips to both top-of-banks. The rail level at the crossing of the River Pinn will be approximately 48.7m AOD.

8.2.9 The River Pinn is currently tightly constrained under the existing viaduct downstream of the new crossing. The underbridge will be designed to span the River Pinn with no piers within the span and the minimum soffit will be set approximately 8m above the existing ground level. The width of the underbridge will be significantly greater than the existing downstream crossing and therefore no significant flood flow obstruction is expected. The footpath crossing of the River Pinn will continue to use the existing footbridge.

8.2.10 The presence of built volume within the floodplain in the form of approach embankments totalling 150m in length will displace flood waters and will consequently have an impact on flood water levels upstream.

8.2.11 The land use upstream of the crossing is comprised of Ruislip Golf Course (low value receptor), agricultural land (moderate value), and the residential properties of Oak Farm, Square Orchard and Dunster Cottage (high value).

8.2.12 Replacement upstream floodplain storage will be provided to mitigate for any loss of floodplain storage as a result of the proposed approach embankments for the crossing of the River Pinn.

8.2.13 There will be no resulting change in upstream or downstream water levels during flood events as a result of the Proposed Scheme at the River Pinn.

Newyears Green Bourne at Harvil Road

8.2.14 Replacement upstream flood storage will be provided to mitigate for any loss of floodplain storage as a result of the proposed approach embankments for the Harvil Road diversion crossing of the Newyears Green Bourne.

8.2.15 There will be no resulting change in upstream or downstream water levels during flood events as a result of the Proposed Scheme at the Harvil Road diversion.

8.3 Impact on risk of flooding from surface water

8.3.1 The above ground infrastructure within the study area has the potential to alter overland flow routes thereby changing the risk of flooding to local receptors.

South Ruislip vent shaft

8.3.2 The South Ruislip vent shaft will be located on brownfield land that has been previously developed. There will be a permanent headhouse structure and associated hardstanding. It is estimated that the total impermeable area at the vent shaft will be

approximately 0.34ha. Surface water runoff from the headhouse and hardstanding will be controlled at source and attenuated using below-ground storage approximately 150-250m^3 in volume. Surface water runoff will then be discharged to the local 450mm diameter TWUL sewer in Victoria Road at a rate of approximately 4ol/s.

8.3.3 This arrangement will prevent increased rates and volumes of surface water runoff flowing to the local sewer network or to above ground receptors. The Proposed Scheme will therefore not lead to a change in the risk of surface water flooding at the South Ruislip vent shaft.

Ruislip Golf Course

8.3.4 There are a number of land drainage ditches within Ruislip Golf Course that generally flow to the north-west towards various outfalls with the River Pinn. The potential effect on the Ickenham Stream, which flows through the golf course, has been previously described in Section 7 of this report. There are, however, areas shown to be at risk of surface water flooding. Permanent infrastructure, including the diverted channel of the Ickenham Stream, will not extend far into the golf course.

8.3.5 Surface water captured within the catchment of the West Ruislip portal will be collected and attenuated using storage of approximately 1,200-1,600m^3. Collected surface water will then be discharged to the 225mm diameter TWUL sewer in Ickenham road at a rate of 8.3l/s.

8.3.6 The Proposed Scheme will therefore not lead to a change in the risk of surface water flooding at Ruislip Golf Course.

Chiltern Main Line to the north of Copthall Covert

8.3.7 Surface water runoff within the proposed cutting will be controlled at source within the railway drainage system. The cutting will be separated from the existing cutting of the CML through the provision of landscape mitigation earthworks.

8.3.8 The Proposed Scheme will therefore not lead to a change in the risk of surface water flooding in the cutting of the CML.

8.4 Impact on risk of flooding from groundwater

8.4.1 Where there is an existing susceptibility to groundwater flooding the Proposed Scheme will be in tunnel (Ruislip Gardens depot), or on a bridge (River Pinn). The impact assessment on groundwater within the study area (Volume 5: Appendix WR-002-006) reports that there are no anticipated effects to groundwater in this location.

8.4.2 The Proposed Scheme will therefore not lead to a change in the risk of flooding from groundwater.

8.5 Impact on risk of flooding from drainage systems

8.5.1 Connections to the foul and surface water sewer network within the study area will be agreed with TWUL prior to construction. There will not be a significant increase in the area of impermeable surface. In addition, surface water runoff from permanent

infrastructure will be attenuated to greenfield rates before being discharged to a local watercourse or to the public sewer network. Consent for discharge will be obtained prior to construction from the necessary statutory authorities to ensure that there is sufficient capacity in the receiving infrastructure.

8.5.2 The Proposed Scheme will therefore not lead to a significant change in the risk of flooding from drainage and sewer systems.

8.6 Impact on risk of flooding from artificial sources

Canals

8.6.1 There are no canals within the study area and therefore the Proposed Scheme will not lead to a change in the risk of flooding from canals.

Impounded reservoirs

8.6.2 The embankments at the viaduct crossing of the River Pinn will encroach into the area shown to have a residual risk of flooding due to a failure of Ruislip Lido. Although there is a potential impact on the residual risk of flooding from the reservoir, since this water body is subject to the requirements of the Reservoirs Act 1975 (as amended), the likelihood of such flooding occurring is extremely low. Mitigation measures employed against the potential impact on flooding from the River Pinn will apply to the risk of flooding from Ruislip Lido. The impact of the Proposed Scheme on the actual risk of flooding from impounded reservoir failure will be negligible.

Water mains

8.6.3 The potential damage to TWUL assets will be assessed prior to construction, and measures put in place to prevent the failure of any water main. Water main diversions will be constructed using appropriate materials and methods to ensure that the risk of failure is minimal.

8.6.4 The Proposed Scheme will therefore not lead to a change in the risk of flooding from water mains.

8.7 Summary of potential impacts and effects on flood risk

Table 6: Summary of potential flood risk impacts and effects in CFA6

Receptor	Vulnerability classification	Pathway	Impacts and effects
General Proposed Scheme		River	No significant effects expected.
		Surface water	No significant effects expected.
		Groundwater	No significant effects expected.
		Drainage systems	No significant effects expected.
		Artificial sources	No significant effects expected.
South Ruislip industrial area	Less vulnerable	Surface water 30 years - shallow	No significant effects expected.

Receptor	Vulnerability classification	Pathway	Impacts and effects
South Ruislip urban centre	More vulnerable	Flood Zone 2 and Flood Zone 3	No significant effects expected.
Ruislip Gardens urban centre	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 30 years - shallow	No significant effects expected.
Ruislip Gardens LU Depot	Less vulnerable	Groundwater - high	No significant effects expected.
West Ruislip LU Station	Less vulnerable	Surface water 200 years - shallow	No significant effects expected.
The Greenway, West Ruislip	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow	Surface water runoff will be collected and attenuated before being discharged to the diverted TWUL sewer to the west of the existing culvert.
Ruislip Golf Course	Water compatible	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow	No significant effects expected.
Oak Farm, Square Orchard and Old Priory	More vulnerable	Edge of Flood Zone 2 and Flood Zone 3	No significant effects expected.
Schering-Plough Animal Research Facility	Less vulnerable	Edge of Flood Zone 2 and Flood Zone 3	No significant effects expected.
CML cutting	Less vulnerable	Surface water 200 years - shallow	No significant effects expected.

9 Conclusions

9.1 Summary

9.1.1 The Proposed Scheme within CFA6 extends from a point to the south of Rabournmead Drive in the east to Harvil Road in the west. The study area includes all areas within 500m of the Proposed Scheme, which includes:

- areas at risk of flooding from the Yeading Brook eastern arm and the Yeading Brook western arm,
- the Ickenham Stream, the River Pinn, and Newyears Green Bourne;
- areas at risk of surface water flooding;
- areas with the potential for elevated groundwater; and
- areas with a residual risk of flooding due to the failure of Ruislip Lido.

9.1.2 The Proposed Scheme will be at least 1m above design flood water levels within all areas at risk of flooding from rivers, drainage and artificial water body sources. Residual risks from these sources will be negligible.

9.1.3 CFA6 is heavily urbanised, with substantial residential and industrial areas. There will be no third party receptors that will be significantly affected by the Proposed Scheme.

9.2 Residual flood risks to Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from rivers

9.2.2 There are no locations within CFA6 where the failure or blockage of a hydraulic structure would lead to an increase in the severity of flooding sufficient to create a residual risk of flooding to the Proposed Scheme.

Residual flood risks from surface water and minor watercourses

9.2.3 All culverts within the Proposed Scheme are designed with a minimum internal headroom of 600mm above the design flood water level to minimise the risk of blockage. There is not expected to be any significant increased risk of flooding at minor watercourses and dry valley crossings arising from potential blockage of culverts.

9.2.4 There are no minor watercourse crossings within CFA6 where significant hydraulic structures exist within a reasonable hydraulic distance either upstream or downstream that could create significant additional risks of flooding to the Proposed Scheme due to blockage or failure.

Residual flood risks from groundwater

9.2.5 Groundwater levels rise and fall relatively slowly and for any change to occur in the risk of flooding from this source below ground intervention is required. The risk of flooding from groundwater already considered therefore presents an absolute risk and there are no significant residual risks arising from this source.

Residual flood risks from drainage systems

9.2.6 There are no areas within CFA6 where a significant risk of flooding exists from drainage systems or artificial sources. Consequently, there are no expected residual risks from these sources.

Residual flood risks from artificial and surface waterbodies

9.2.7 Within CFA6, the only area of flood risk associated with an artificial or surface waterbody is the inundation area associated with failure of Ruislip Lido. The Environment Agency methodology considers the consequences of total failure of the reservoir and therefore no further residual risks arise.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 Following mitigation for impacts on the risk of flooding arising from the Proposed Scheme there will be no significant residual effects on the risk of flooding.

9.4 Compliance with local planning policy

9.4.1 The Proposed Scheme includes an allowance for future increases in the risk of flooding as a result of climate change by adding a 20% increase to design river flows and a 30% increase to rainfall intensities and flows in minor watercourses as recommended in the NPPF Technical Guidance document. SuDS, in the form of attenuation ponds and creation of open channel land drainage, are used wherever feasible in CFA6. The Proposed Scheme will be in compliance with the Thames Region CFMP and the London Plan.

9.4.2 Although not in direct contravention of the Thames Region CFMP, the introduction of additional culverts is at variance with the general aims of the CFMP which seeks to restore culverted watercourses and enhance natural floodplain. In addition, the LBHi SFRA stipulates that "development should provide compensatory storage on a level-for-level basis to ensure there is no loss in flood storage capacity". Mitigation will be provided in the form of replacement floodplain storage as part of the Proposed Scheme to offset losses in natural storage capacity. Although minimised wherever possible there is no practical way to avoid culverting and floodplain crossings due to the linear nature of the Proposed Scheme. The Ickenham Stream will be diverted in an open channel to the River Pinn and the River Pinn will be crossed on a clear-span structure with access alongside the watercourse maintained. Therefore the Proposed Scheme is consistent with the requirements of the LBHi Core Strategy.

10 References

Capita Symonds (2011), *London Borough of Hillingdon Preliminary Flood Risk Assessment.*

Capita Symonds (2013), *London Borough of Hillingdon Surface Water Management Plan.*

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